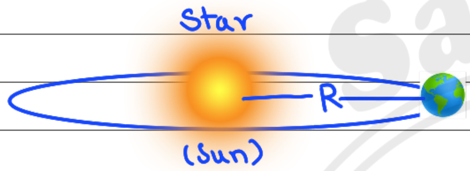
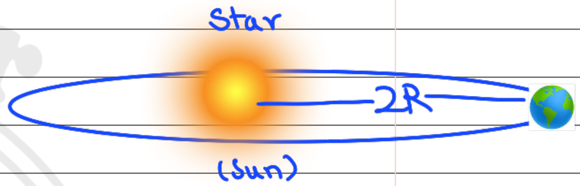
Q.1 Let the period of revolution of a planet at a distance R from a star be T.
Prove that if it was at a distance of 2R from the star, its period of revolution will be $\sqrt{8}\,T$.

Solution :-





Distance from star = R
Time of rotation = T

Distance from star = 2R
Time of rotation = T_N (new time)

According to Kepler's law

$$\frac{T^2}{R^3} = K \quad \ldots (i)$$

$$\frac{T_N^2}{(2R)^3} = K \quad \ldots (ii)$$

Comparing eq (i) and (ii)

$$\frac{T^2}{R^3} = \frac{T_N^2}{(2R)^3}$$

$$\frac{T^2}{R^3} = \frac{T_N^2}{8R^3}$$

$$\therefore T^2 = \frac{T_N^2}{8}$$

$$\therefore T_N^2 = 8T^2$$

Taking square root out

$$T_N = \sqrt{8}\,T$$

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Q.2 A stone thrown vertically upwards with initial velocity u reaches a height 'h' before coming down. Show that the time taken to go up is same as the time taken to come down.

Solution:-

When object is thrown up

Initial velocity = u
Final velocity = 0
Acceleration = $-g$ (when object thrown up)
Time taken = t_1

According to 1st kinematical equation

$$v = u + at$$
$$0 = u - gt_1$$
$$\therefore gt_1 = u$$
$$\therefore t_1 = \frac{u}{g} \quad \ldots (i)$$

When object falls down

Initial velocity = 0
Final velocity = u
Acceleration = $+g$ (when object falls down)
Time taken = t_2

According to 1st kinematical equation

$$v = u + at$$
$$u = 0 + gt_2$$
$$u = gt_2$$
$$\therefore t_2 = \frac{u}{g} \quad \ldots (ii)$$

from eq (i) and (ii)

$$t_1 = t_2$$

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Q.3 An object takes 5 sec to reach the ground from a height of 5m on a planet. What is the value of g on the planet.

Solution :

Displacement (s) = 5 m

Time (t) = 5 sec

Initial velocity (u) = 0 m/s

Acceleration due to gravity (g) = ?

According to 2nd Kinematical equation

$$S = ut + \frac{1}{2}at^2$$

$$5 = (0)(5) + \frac{1}{2}g(5)^2$$

$$5 = 0 + \frac{25}{2}g$$

$$5 = \frac{25}{2}g$$

$$\therefore g = \frac{5 \times 2}{25} = \frac{10}{25} = \frac{2}{5} = 0.4\ m/s^2$$

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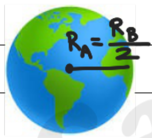
Q.4 The radius of planet A is half the radius of planet B. If mass of A is M_A, what must be the mass of B so that the value of g on B is half that of its value on A?

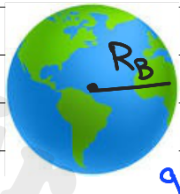
We have
$R_B = 2R_A$

(A)



g_A

(B)



$g_B = \frac{g_A}{2}$

We have
$g_A = 2g_B$

To find: Mass of planet B, $M_B = ?$

Formula: $g = \frac{GM}{R^2}$

For planet 'A'

$$g_A = \frac{GM_A}{R_A^2} \quad \ldots\ldots (i)$$

For planet 'B'

$$g_B = \frac{GM_B}{R_B^2} \quad \ldots\ldots (ii)$$

Dividing equation (ii) by (i)

$$\frac{g_B}{g_A} = \frac{\frac{\cancel{G}M_B}{R_B^2}}{\frac{\cancel{G}M_A}{R_A^2}} = \frac{M_B}{R_B^2} \times \frac{R_A^2}{M_A}$$

$$\frac{g_B}{g_A} = \frac{M_B}{M_A} \times \frac{R_A^2}{R_B^2} = \frac{M_B}{M_A} \times \frac{R_A^2}{(2R_A)^2} = \frac{M_B}{M_A} \times \frac{\cancel{R_A^2}}{4\cancel{R_A^2}}$$

$$\frac{g_B}{g_A} = \frac{M_B}{M_A} \times \frac{1}{4}$$

$$\therefore \frac{\cancel{g_B}}{2\cancel{g_B}} = \frac{M_B}{M_A} \times \frac{1}{4}$$

$$\frac{1}{2} = \frac{M_B}{M_A} \times \frac{1}{4}$$

$$\frac{\cancel{4}^{2}}{\cancel{2}} = \frac{M_B}{M_A}$$

$$2 = \frac{M_B}{M_A}$$

$$\therefore M_B = 2M_A$$

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